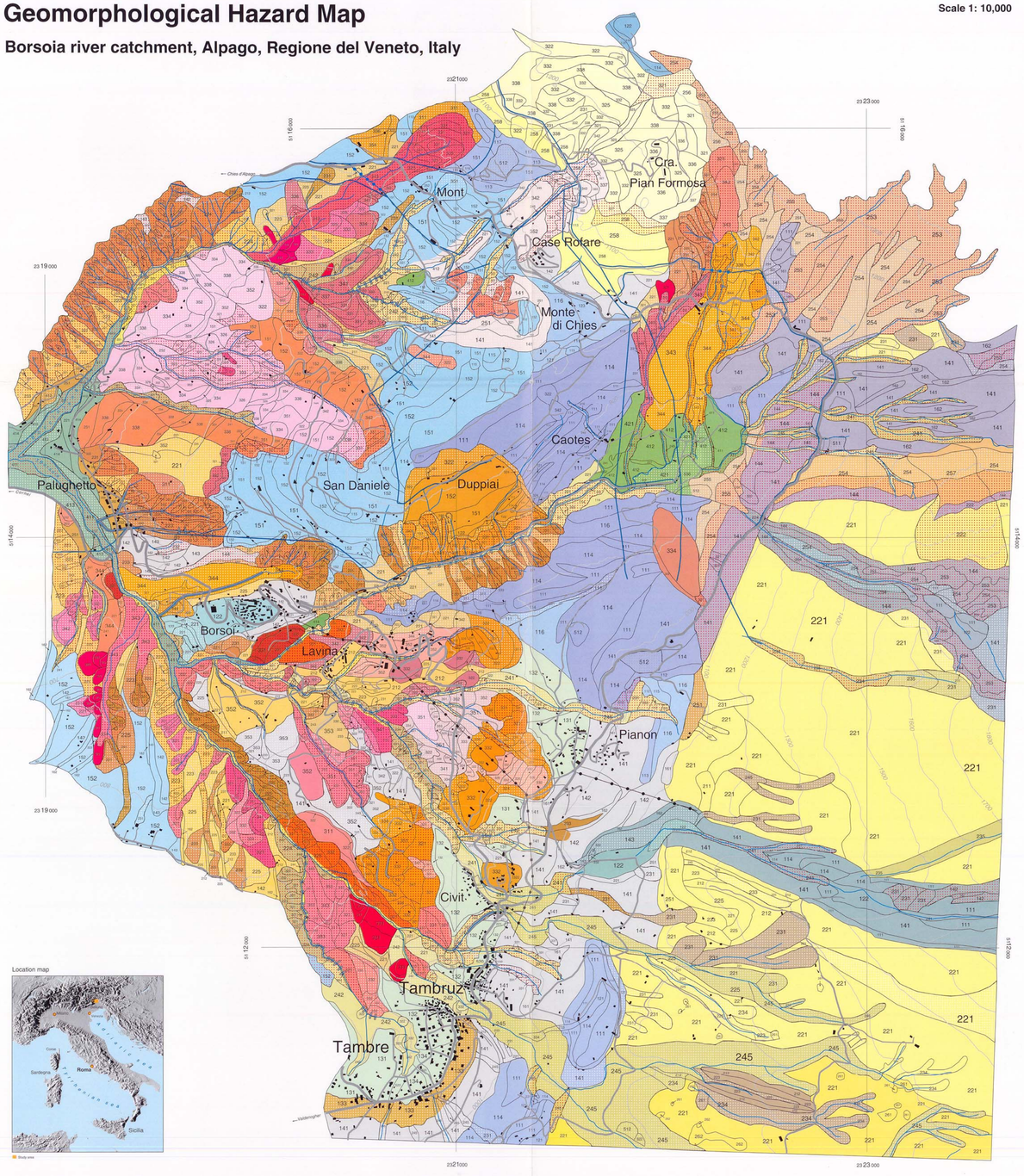
Geomorphological Hazard Map

Borsoia river catchment, Alpago, Regione del Veneto, Italy

Scale 1: 10,000



Location map

Hazard classification

Low hazard. In these areas no destructive phenomena (landslides, rockfall, inundations) are expected to occur within the coming decade, given that the landuse situation remains the same. Inadequate construction of infrastructure or buildings may lead to problems, however.

Moderate hazard. In these areas there is a moderate probability that destructive phenomena will occur that may damage existing infrastructure or buildings. However, the damage is expected to be localized and can be prevented or evaded by relatively simple stabilization measures.

High hazard. In these areas there is a high probability that destructive phenomena will occur. These are expected to damage infrastructure or buildings considerably. It is advised not to construct new infrastructure or buildings, or at least only after detailed study.

Quarries. The hazard degree is related to quarrying activities

Main Geomorphological units

Landforms modelled by glacial processes

Landforms related to the PIAVE glacier

- Ice–marginal complexes related to maximum glaciation
- Ice–marginal complexes related to the contact of the Piave glacier with local glaciers
- Complex of glacially eroded slopes and levels (partly ice–marginal) related to recession phases
- Fluvioglacial fans
- Subglacial till levels with fluvioglacial reworking
- Glacially eroded slopes
- Glacially eroded preglacial landslide niches

Landforms related to the Borsoia glacier

- Ice–marginal complexes related to various recession phases
- Glacially eroded slopes

Landforms related to minor local glaciers

- Morainic complex of maximum glaciation
- Cirque
- Glacially eroded valley
- Fluvio–glacial fans

Landforms modelled by denudational processes

Denudational plateaus

- In calcareous rocks with minor karstification processes

Denudational slopes

- In calcareous rocks
- In flysch
- In morainic material

Accumulation of slope deposits

- Scree slopes
- Rockfall deposits
- Colluvial slopes

Denudational niches

- In calcareous rocks
- In flysch rocks
- In morainic materials

Denudational valleys

- In calcareous rocks
- In flysch rocks
- In morainic materials
- In mass movement materials

Landslides

Preglacial landslides

- Collapsed cemented scree slope complex, with clear landslide blocks
- Collapsed cemented scree slope complex, with chaotic landslide mass

Early postglacial landslides

- Dipslope related
- Failure of subglacial till level
- Flow–mass, caused by loading of scree material on top of flysch
- Rotational landslide in moraine covered flysch
- Landslide in ablation moraine

Sub–recent Holocene landslides

- Reactivation of older landslide: dipslope related
- Reactivation of older landslide: failure of subglacial till level
- Reactivation of older landslide: contact of moraine and flysch
- Reactivation of older landslide: related to other situations
- New landslide: dipslope related
- New landslide: faceslope related
- New landslide: failure of subglacial till
- New landslide: contact of moraine and flysch
- New landslide: due to stream undercutting
- New landslide: related to other situation

Recent landslides

- Reactivation of older landslide: dipslope related
- Reactivation of older landslide: contact of moraine and flysch
- Reactivation of older landslide: related to other situations
- New landslide: dipslope related
- New landslide: faceslope related
- New landslide: contact of moraine and flysch
- New landslide: due to stream undercutting

Alluvial landforms

- Floodplain and terraces of Borsoia and Boccolana rivers
- Alluvial fans in Borsoia glacial valley

Geomorphological sub–units

Glacial landforms

Ablation moraine

111 Ridges
112 With ice–pushed structures
113 With collapse structures
114 Side slopes of ridges
115 Dead ice depression
116 Dead ice complex with fluvioglacial reworking
117 Dead ice complex with in contact with preglacial landslide deposits

Fluvioglacial landforms

121 Ice–marginal valley
122 Ice–marginal alluvial fan
123 Fluvioglacial terrace

Sub–glacial till levels

131 Without cover
132 With fluvioglacial fan cover
133 With cover of slope deposits
134 With minor surficial mass movements

Glacially eroded slopes

141 Without clear structural control
142 Dipslopes
143 Facesloples
144 Rockfall producing glacially eroded cliffs

Glacially eroded slopes and levels with subglacial till and or ablation till

151 Slopes
152 Levels

Glacially eroded ridges

161 Without clear structural control
162 With structural control

Denudational landforms

Denudational ridges

211 Without structural control
212 With structural control

Denudational slopes

221 Without clear structural control: Not rockfall producing
222 Without clear structural control: rockfall producing
223 Face slopes: not rockfall producing
224 Face slope: rockfall producing
225 Dipslopes

Denudational niches

231 Without clear structural control
232 In faces slopes
233 In dipslopes
234 With karstification
235 Fault related

Denudational valleys

241 With active erosion, without checkdams
242 With active undercutting, with checkdams
243 Valley closed by landslides, without checkdams
244 Valley closed by landslides, with checkdams
245 Without active erosion

Slope deposits

251 Colluvial slopes
252 Colluvial fans
253 Active scree slope
254 Non–active scree slope (vegetation)
255 Active scree cone
256 Non active scree cone
257 Rockfall material
258 Cemented scree slope

Karst features

261 Doline
262 "Sink hole"

Mass movement features

Initiating landslides

311 Initiating landslide body
312 Tension cracks, depression

Scarps

321 Back scarp, showing signs of recent activity
322 Back scarp, no signs of recent activity
323 Side scarp, showing signs of recent activity
324 Side scarp, no signs of recent activity
325 Intermediate scarp, showing signs of recent activity
326 Intermediate scarp, no signs of recent activity

Slide features

331 Top of rotational landslide body, recent activity
332 Top of rotational landslide body, no recent activity
333 Top of translational landslide body, recent activity
334 Top of translational landslide body, no recent activity
335 Top of complex landslide body, recent activity
336 Top of complex landslide body, no recent activity
337 Side slope of landslide body, recent activity
338 Side slope of landslide body, no recent activity

Flow features

341 Flowslide mass, recent activity
342 Flowslide mass, no recent activity
343 Flow mass, recent activity
344 Flow mass, no recent activity

Surficial mass movements on slope

351 Predominantly flow type mass movements, active
352 Predominantly flow type mass movements, not active
353 Predominantly slide type mass movements, active
354 Predominantly slide type mass movements, not active

Alluvial landforms

411 Alluvial valley floor
412 Alluvial fan
413 Low terrace
414 High terrace

Anthropogenic landforms

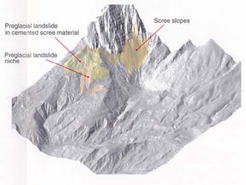
511 Quarry
512 Gravel pit
520 Landfill
530 Excavated area

Topography

- Main road
- Minor road
- Unpaved road
- Power line
- Ski lift
- Drainage line
- Aquaduct
- Water pipe
- Concrete drainage channel
- Check dam
- Building
- 1200 — 100 meter index–contourline
- Boundary of geomorphological sub units

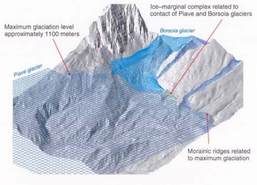
Geomorphological evolution of the study area

Preglacial situation



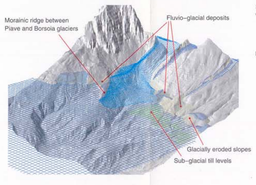
Some preglacial landforms can still be found in the study area, above 1100 meters. In the area surrounding Casera Pian Formosa a heterogeneous terrain exists, with of a number of blocks, underlain with cemented scree material. Since the toe of this slide is reworked by glacial processes, it can be concluded that the landslide is of preglacial age. Two large niches near Case Rofare and Monte de Chies have evi–dences that they were originated by landslides before the last glaciation. In both glacial landforms are found. Parts of the scree slope in the NE are also preglacial.

Situation during maximum glaciation



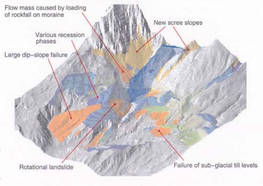
During the maximum extension of the last ice age the main Piave glacier covered nearly the entire study area up to an elevation of approximately 1100 meters. A series of ice–marginal complexes marks the maximum advance. Some of the morainic materials show ice–pushed structures, and in other places collapse struc–tures are found. The Borsoia glacier did not have the power at that time to advance very far. A contact zone between moraines from the Piave and the Borsoia glaciers is found in the area NE of Pianon. Also some small local glaciers existed.

Situation during early deglaciation



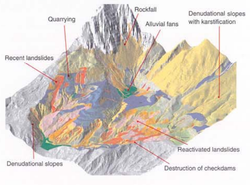
After the maximum glaciation phase the Piave glacier retreated, allowing the Borsoia glacier to advance. A large medial moraine was formed in the area between Caotes and Monte de Chies. Also some fluvio–glacial deposits were formed in this period. In the entire area between Tambre and Pianon a thick deposit of sub–glacial till was formed with a relatively flat surface. This surface was later partly covered with fluvio–glacial materials. Due to the geotechnical characteristics of the sub–glacial till, this material is very vulnerable to landslides. Other local glaciers became less important.

Situation during late deglaciation



At the end of the last glaciation, the main Paive glacier had retreated from the area leaving a series of ice–marginal levels in the area surrounding San Daniele. The Borsoia glacier still remained, building up a series of morainic ridges in the area SE of Caotes. Large landslides occurred, due to glacial overesteepening, especially in the area NW of San Daniele, where a large dipslope failure occurred, and in the Duppiai area, where a large rotational failure took place, with small displacements. In the Tambre area a series of flowslides in the sub–glacial till level took place.

Present situation



During the Holocene mass movement activity remained high. Older landslides were reactivated and many new ones occurred. The following conditions are the most critical: stream undercutting, dipslopes in Flysch rocks, the loading of rockfall mate–rial on top of fine–grained soils, and the contact between permeable and impeme–able materials. During the last century deforestation was important, since most of the area was used for agriculture. During the last decades there was a shift to tou–rism. Many of the recently built checkdams are already destroyed by landslides.

INTERNATIONAL INSTITUTE FOR AEROSPACE SURVEY AND EARTH SCIENCES
ITC P.O.Box 6, 7500 AA Enschede, The Netherlands

Data processing software: ILWIS

Cartographic software: ACE

Data collection: C.J. van Westen and R. Soeters

Data processing: C.J. van Westen

Digital cartographic processing: K. Sijmons and C.J. van Westen

How the map was constructed:

This geomorphological hazard map was constructed with the so–called "direct hazard mapping" method. First a detailed photo–interpretation was performed with airphotos from 1954 to 1980, having scales ranging from 1:30.000 to 1:10.000. A detailed field–check was made and the resulting geomorphological units (mainunits and sub–units) were drawn on 1:5.000 scale topographical maps. The following map–sheets were used: 064064 (Tambre d'Alpago), 064023 (Case Rolfare), 064012 (Chies d'Alpago) and 064051 (Borsoi), from the "Regione del Veneto, Segretaria regionale per il Territorio, Ufficio Cartografico". The hazard classification was done afterwards.

For each hazard polygon the deciding factors for the hazard classification were recor–ded in a data–base. In this map only the geomorphological factors are indicated. For reasons of clarity the hazard types are also not indicated (different landslide types, rockfall, inundations). All factors can be evaluated in the digital version.